XA0200100 IAEA-SM-367/B/10/05/P

PHYSICOCHEMICAL CHARACTERISTICSOF URANIUM MICROPARTICLES COLLECTED AT NUCLEAR FUEL CYCLE PLANTS

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Any industrial process is accompanied by appearance of some quantity of microparticles of processed matter in the environment in immediate proximity to the manufacturing object. These particles can be transferred in atmosphere and can be collected at some distances from the plant.

The determination of characteristics of industrial dust microparticles at nuclear fuel cycle plants (form, size, structure of surface, elemental composition, isotopic composition, presence of fission products, presence of activation products) in conjunction with the ability to connect these characteristics with certain nuclear manufacturing processes can become the main technical method of detecting of undeclared nuclear activity.

Systematization of the experimental data on morphology, elemental and isotopic composition of uranium microparticles, collected at nuclear fuel cycle plants, is given in Report / 1 / and Atlas / 2 /. The purpose of this work is to establish the relationship between morphological characteristics of uranium dust microparticles and types of nuclear manufacture and to define the reference attributes of the most informative microparticles.

All investigated aerosol uranium microparticles in the regions of uranium ore mining are characterized by an extremely irregular form such as debris or scales. The sizes of an overwhelming majority of the particles collected in immediate proximity to a ventilating air-gusher of the mine are within tens of microns, mainly from 10 μm to 50 μm. As a rule, these particles are composite and are represented by agglomerates of micron-sue objects of irregular form. The particles collected at 15 kms' distance from the mine are within units of microns mainly from 2 μm to 3 μm, and have the form of scales. All aerosol uranium microparticles in the regions of uranium ore mining include oxygen and silicon besides uranium, and almost all include calcium, aluminum and iron. Isotopic composition of uranium in all these particles is natural, of course.

Presence of spherical uranium microparticles with fluorine and oxygen in samples, collected at the plant or near the plant, specifies the process of uranium isotopes' separation in a uranium hexafluoride. Most of these spherical particles have sizes from 1 μm to 2 μm. Often in samples, collected at enrichment plants using gaseous technologies, conglomerates of spherical particles are found. The particles in conglomerates also consist of uranium, fluoride and oxygen. Sizes of these particles are from 0.3 μm to 0.6 μm as a rule. Isotopic compositions of uranium in investigated particles correspond to nomenclature of products of this plant.

Production of uranium fuel is accompanied by formation of a great number of particles with irregular form such as debris with a smooth surface, sharp ribs and round holes of caverns. These particles have sizes from 2 μm to 20 μm. Apparently, these particles are formed through splitting as a result of mechanical actions or thermotensions. Caverns on the particles' surfaces are the consequences of air bubbles in the thickness of sintered matter. In addition, particles, having sizes from 2 μm to 10 μm and breccia-like surface with the size of agglomerated objects ranging from 0.1 μm to 0.3 μm characterize this manufacture.

The morphologies of uranium microparticles collected from hot cells, are, appearantely, related to the spent fuel procedures, which are typical for the given hot cell. This thesis is confirmed by the photos of microparticles collected at two different plants using hot cells. Characteristic feature of microparticles from hot cells is registration of fission products, activation products, and plutonium in these particles.

Thus, the information about morphological characteristics of uranium microparticles from industrial dust at nuclear fuel cycle plants, about isotopic composition of uranium in these particles as well as about presence of plutonium, fission products and activation products in these particles can be used nuclear activity types identification.

The data about isotopic composition of uranium and plutonium, about elemental composition of microparticles including uranium and plutonium, about joint presence of uranium and plutonium, uranium and thorium as well as uranium and aluminum, zirconium, lithium, beryllium, oxygen and carbon indicate the purpose of nuclear matter production. Information about form, size, structure of the surface and elemental composition of microparticles can be used to determine technological features of product.

Furthermore, these data indicate the kind of equipment used for separation of uranium isotopes as well as the necessary types of chemical treatment of nuclear matter to transform this matter into weapon matter or the possibility to use the nuclear matter in weapon programs without additional chemical treatment.

Morphological attributes: form, size and structure of the surface of individual microparticles can also be considered as characteristic attributes of formation conditions and, consequently, parameters of informative particles.

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